



ELECTROWEAK & HIGGS PHYSICS AT DØ

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*for the
DØ Collaboration*

<http://www-d0.fnal.gov/Run2Physics/wz/>
<http://www-d0.fnal.gov/Run2Physics/higgs/>

*International Europhysics Conference on High
Energy Physics
Aachen, July 17 – 23, 2003*





Outline

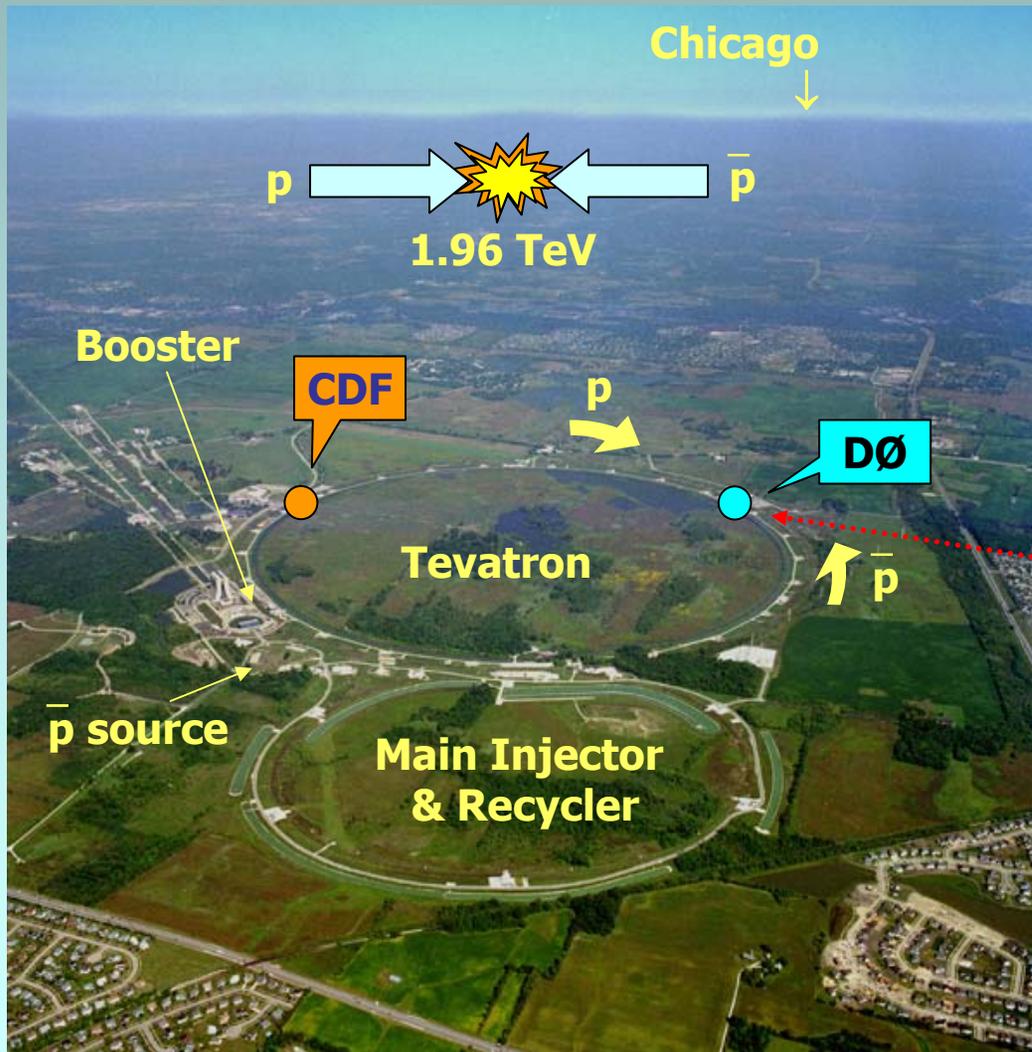
- Status of Run II
- EW Results:
 - $\sigma \times B$ for W & Z
 - e/ μ channels
 - Ratio of W/Z Production Cross Sections
 - Combined Tevatron Results
 - Run II W width
 - Run I W mass & width
- Higgs Studies:
 - WH and ZH Associated Production
 - $H \rightarrow WW^*$ Search
- Summary

*Also: Search on fermiophobic Higgs Searches – Drew Baden
Top Quark Production at the Tevatron – Elizaveta Shabalina
Performance of the DØ experiment in Run II – David Buchholz*



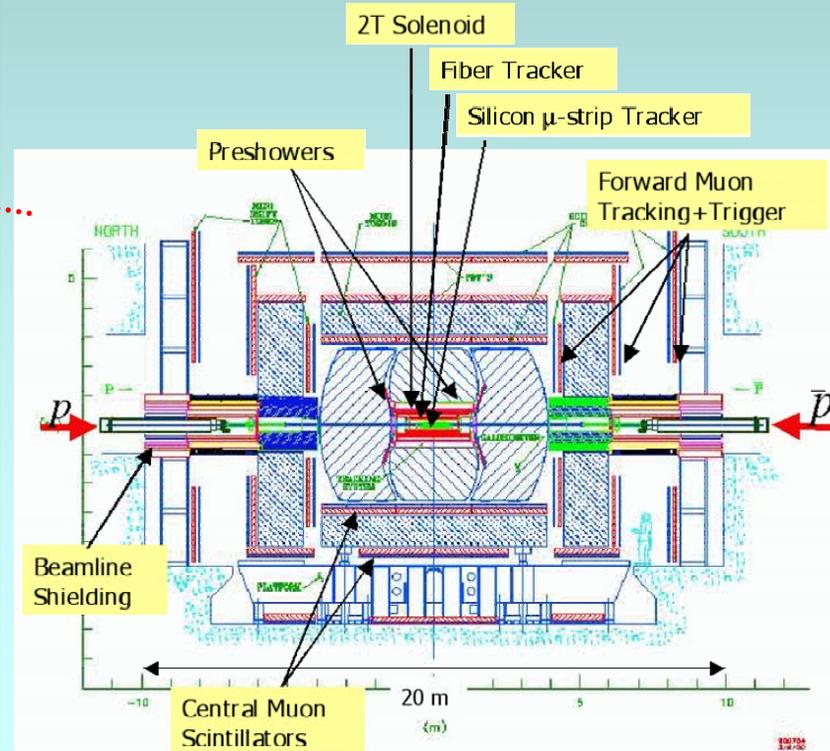


DØ at Fermilab Tevatron-RunII



DØ Upgrade:

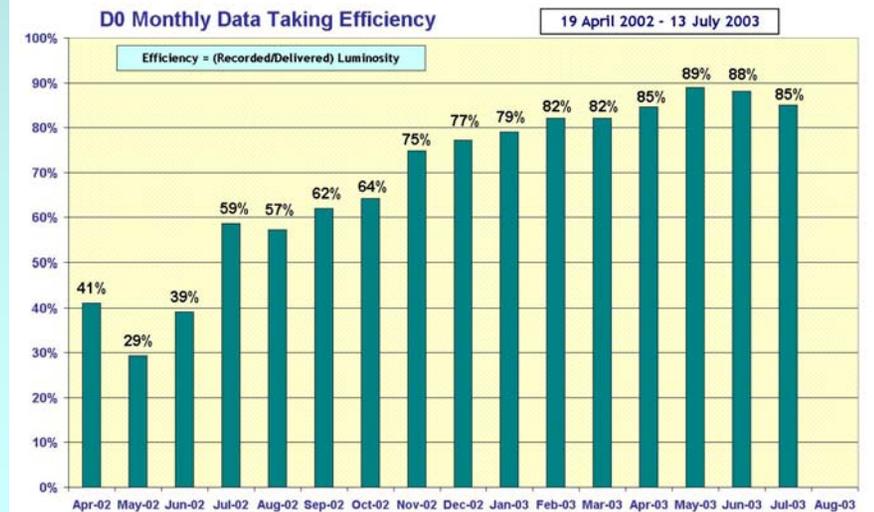
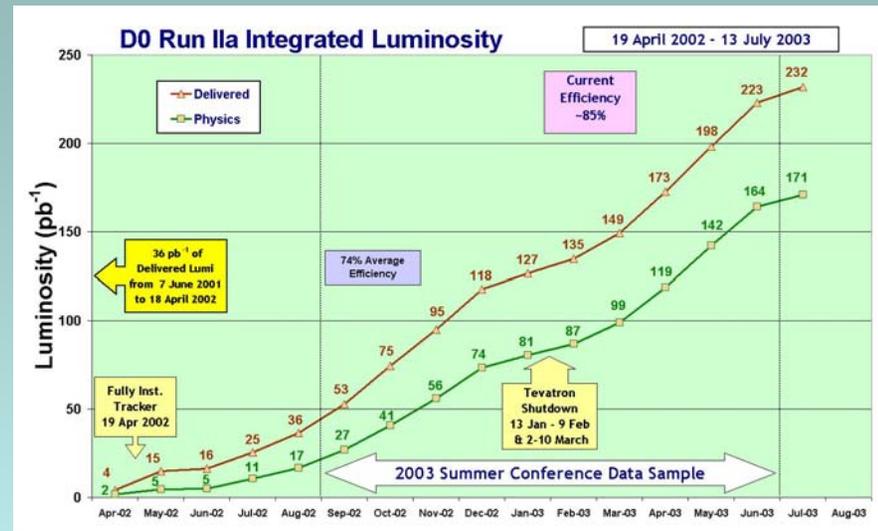
Silicon, fiber tracker, solenoid, muon, daq, trigger, electronics





Data Sample

- Tevatron performance improving
 - Peak luminosity $\sim 4 \times 10^{31}$
- Data samples presented here:
 - 9/02-1/03 ($\sim 50 \text{ pb}^{-1}$)
- Detector data collection efficiency 85-90%



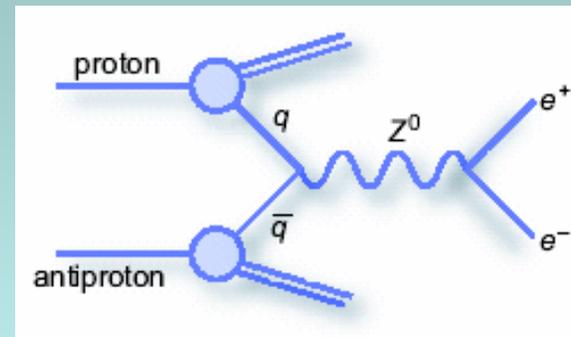
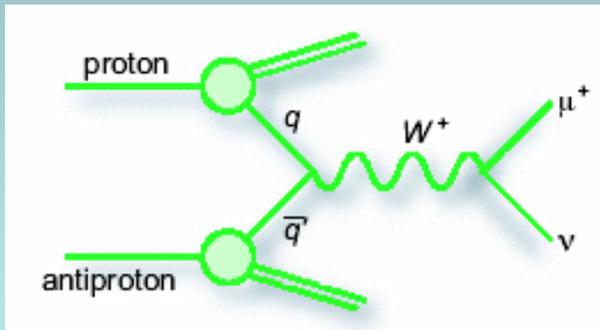


W's and Z's at the Tevatron

- Production dominated by $q\bar{q}$ "annihilation"

- Run II will have $>10^6$ W's & $>10^5$ Z's

$$W \rightarrow l\nu \Rightarrow \sim 1 \text{ Hz @ } L = 2 \times 10^{32}$$



- Use leptonic decays of W and Z

- Avoids large $p\bar{p} \rightarrow jj$ contribution
 - BR $\sim 11\%$ per mode for $W \rightarrow l\nu$
 - BR $\sim 3\%$ per mode for $Z \rightarrow \ell\bar{\ell}$
 - Clean, low background, event signatures
 - High p_T isolated leptons
 - W: 1 high p_T lepton + missing E_T (from ν)
 - Z: 2 high p_T leptons

$$\sigma(p\bar{p} \rightarrow W + X \rightarrow l\nu + X) \approx 2.8 \text{ nb}$$

$$\sigma(p\bar{p} \rightarrow Z + X \rightarrow \ell\bar{\ell} + X) \approx 0.26 \text{ nb}$$

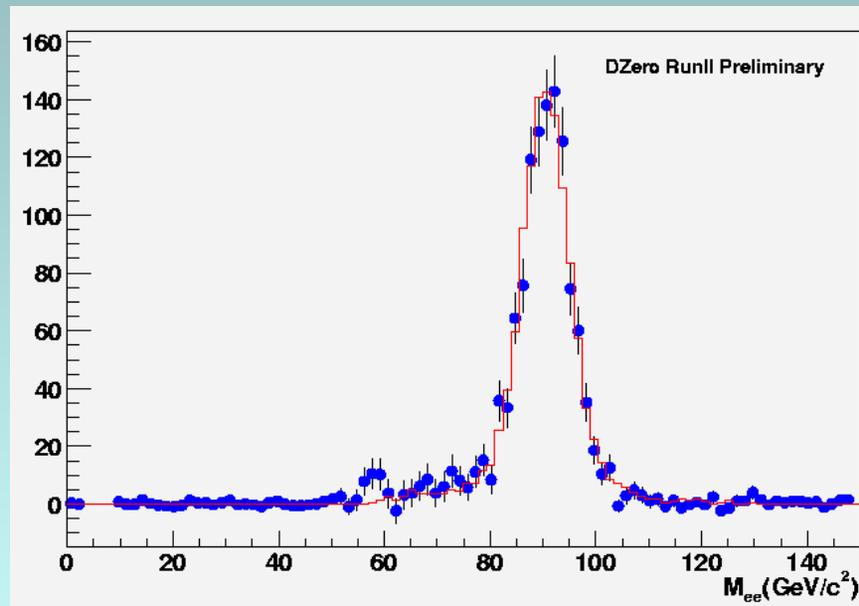

**Cross Sections
increase by
~10% from
1.8 to 1.96 TeV**





Z Production - *Electron Channel*

- $\mathcal{L} \approx 42\text{pb}^{-1}$
- Inclusive single electron trigger
- $|\eta_e| < 1.1, E_T > 25\text{ GeV}$
- No track match required
- Acceptance*Efficiency = 10%
- Drell Yan + interference = 1.7%
- background removed by fitting a scaled shape
- 1139 Z \rightarrow ee final candidates



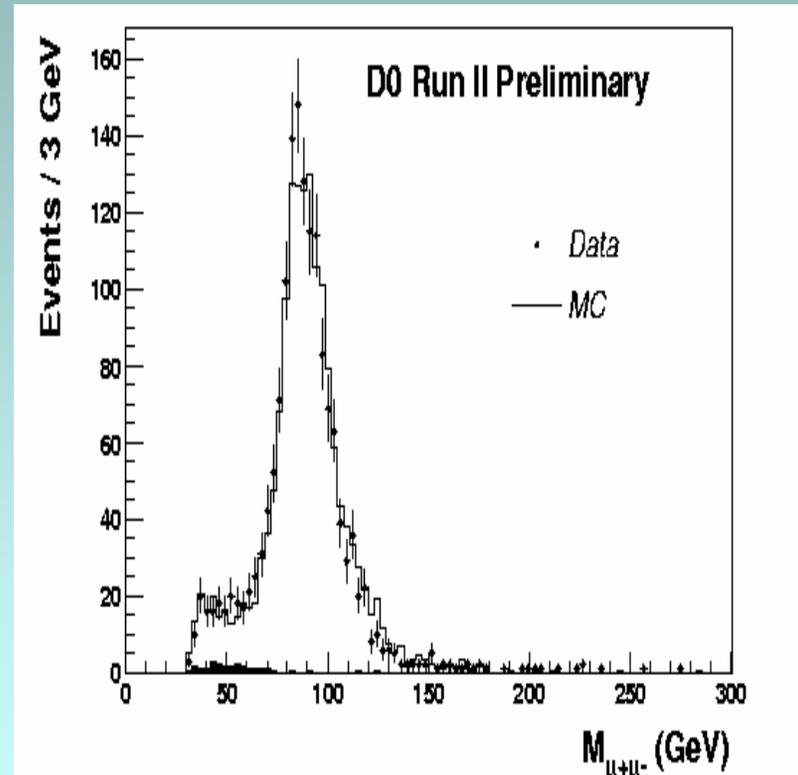
$$\sigma(pp \rightarrow Z) \times B(Z \rightarrow ee) = (275 \pm 9_{stat} \pm 9_{syst} \pm 28_{lum}) pb$$





Z Production - *Muon Channel*

- $\mathcal{L} \approx 32\text{pb}^{-1}$
- Di-muon trigger
- 2 opposite charged muons,
 $|\eta_{\mu}| < 1.8, P_{T}(\mu) > 15\text{ GeV}$
- At least one muon is isolated
- Acceptance*Efficiency = 16%
- Drell Yan + interference = 12%
- Background removed by fitting a scaled shape
- 1585 $Z \rightarrow \mu\mu$ final candidates



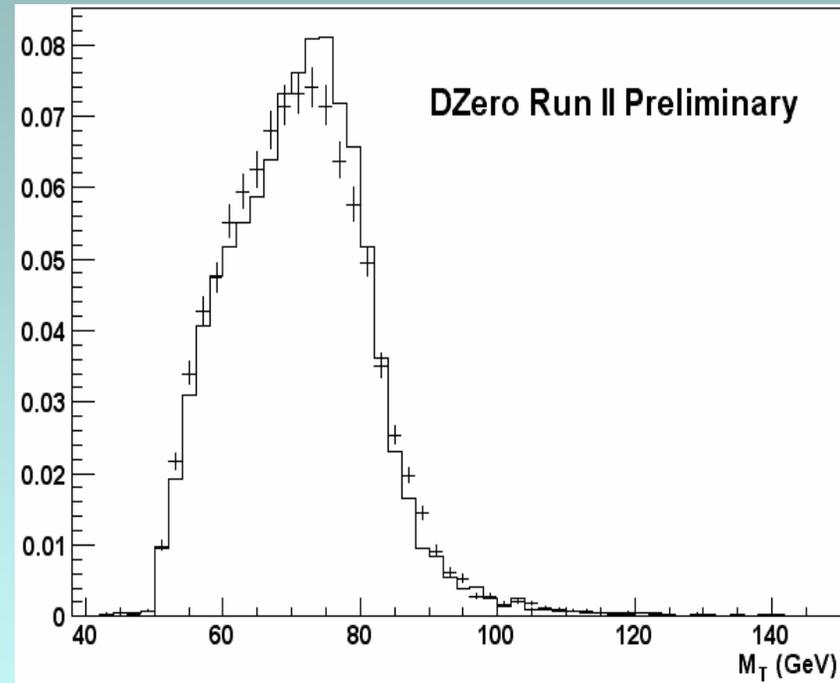
$$\sigma(p\bar{p} \rightarrow Z) \times B(Z \rightarrow \mu\mu) = (264 \pm 7_{stat} \pm 17_{syst} \pm 26_{lum}) pb$$





W Production – *Electron Channel*

- $\mathcal{L} \approx 42\text{pb}^{-1}$
- Inclusive high- p_T single electron trigger
- $|\eta_e| < 1.1, E_T > 25\text{ GeV}$
- $\cancel{E}_T > 25\text{ GeV}$
- Acceptance*Efficiency = 23%
- $W \rightarrow \tau\nu$ (MC, 1.7%), $Z \rightarrow ee$ (negligible) contributions removed
- QCD background evaluated from data (3%)
 - removed using the “matrix method” with track-match cut
- 27370 $W \rightarrow e\nu$ final candidates



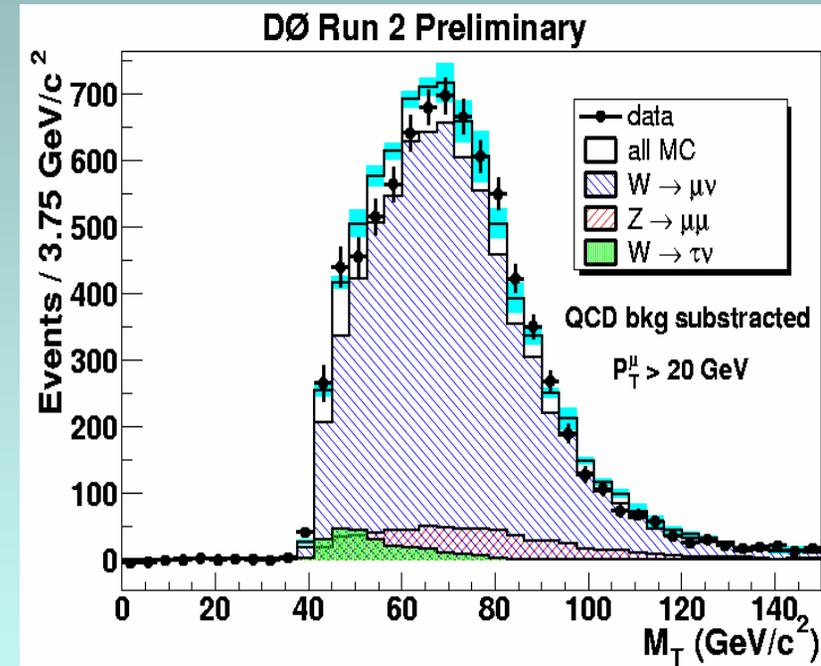
$$\sigma(p\bar{p} \rightarrow W) \times B(W \rightarrow e\nu) = (2844 \pm 21_{stat} \pm 128_{syst} \pm 284_{lum}) pb$$





W Production - Muon Channel

- $\mathcal{L} \approx 17\text{pb}^{-1}$
- Inclusive high- p_T single muon trigger
- $|\eta_\mu| < 1.6, P_T(\mu) > 20 \text{ GeV}$
- $\cancel{E}_T > 20 \text{ GeV}$ (corrected for the muon P_T)
- Acceptance*Efficiency = 13%
- $W \rightarrow \tau\nu$ (4%), $Z \rightarrow \mu\mu$ (9%) contributions removed
- $b\bar{b}$ background evaluated from data (6%)
 - removed using the "matrix method" with isolation cut
- 7352 $W \rightarrow \mu\nu$ final candidates



$$\sigma(p\bar{p} \rightarrow W) \times B(W \rightarrow \mu\nu) = (3226 \pm 128_{stat} \pm 100_{syst} \pm 323_{lum}) \text{ pb}$$

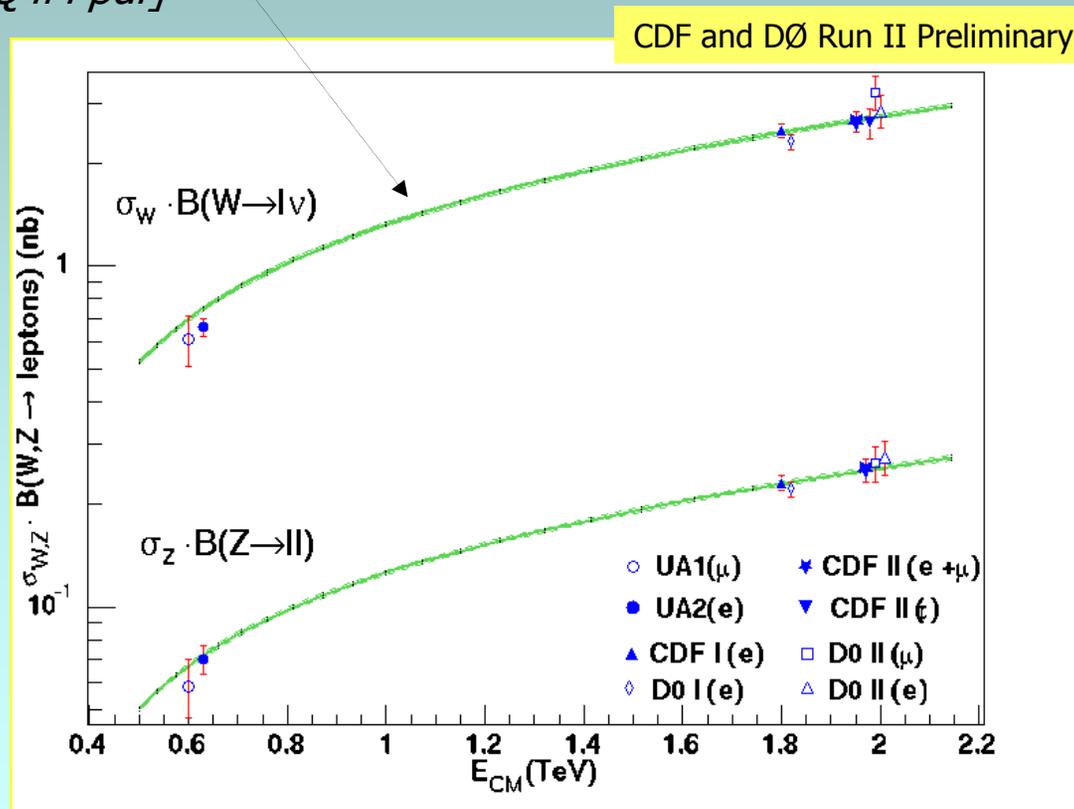




W and Z Cross Section Summary

- Scaling with cm energy consistent

- *CR Hamberg, WL van Neerven and T Matsuura, Nucl. Phys. B359 (1991) 343 [CTEQ4M pdf]*



Measurements consistent with SM predictions





Ratio of W/Z Production Cross Sections

- Use previous $\sigma \times B$ measurements in ratio to extract $\Gamma(W)$ – *Indirect Method*

- Many uncertainties cancel in ratio

$$R = \frac{\sigma(W) \times B(W \rightarrow \ell \nu)}{\sigma(Z) \times B(Z \rightarrow \ell \ell)}$$

Theoretical $\frac{\Gamma^e}{\Gamma(W)}$

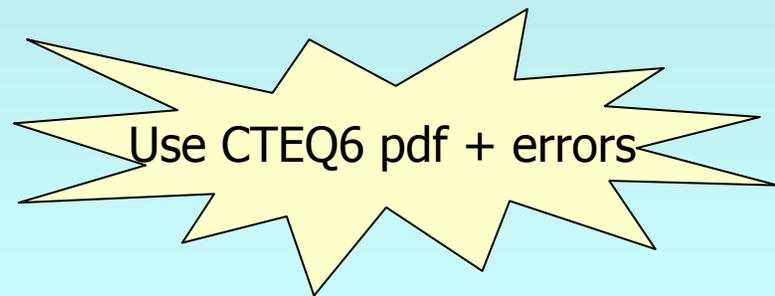
Theory

LEP

- Run II Preliminary:

NEW

$$R_e = 10.34 \pm 0.35_{stat} \pm 0.48_{syst}$$



- Run I DØ Result:

$$R_e = 10.49 \pm 0.14_{stat} \pm 0.21_{syst}$$

Phys. Rev. D **61**, 072001 (2000)



CDF- DØ Combined Results

<http://tevewwg.fnal.gov>



- Extract W width $\Gamma(W)$ from the ratio of W/Z production cross sections:

- CDF Run II Preliminary:

$$R_e = 9.88 \pm 0.24_{stat} \pm 0.47_{syst}$$

$$R_\mu = 10.69 \pm 0.27_{stat} \pm 0.33_{syst}$$

- DØ Run II Preliminary:

$$R_e = 10.34 \pm 0.35_{stat} \pm 0.48_{syst}$$

- Tevatron Run II Preliminary:

NEW

$$R = 10.36 \pm 0.31 \Rightarrow \Gamma(W) = 2.181 \pm 0.073 \text{ GeV}$$

- Tevatron Run I Result:

$$\Gamma(W) = 2.141 \pm 0.057 \text{ GeV}$$

- Tevatron Run I + II Preliminary:

$$\Gamma(W) = 2.150 \pm 0.054 \text{ GeV}$$

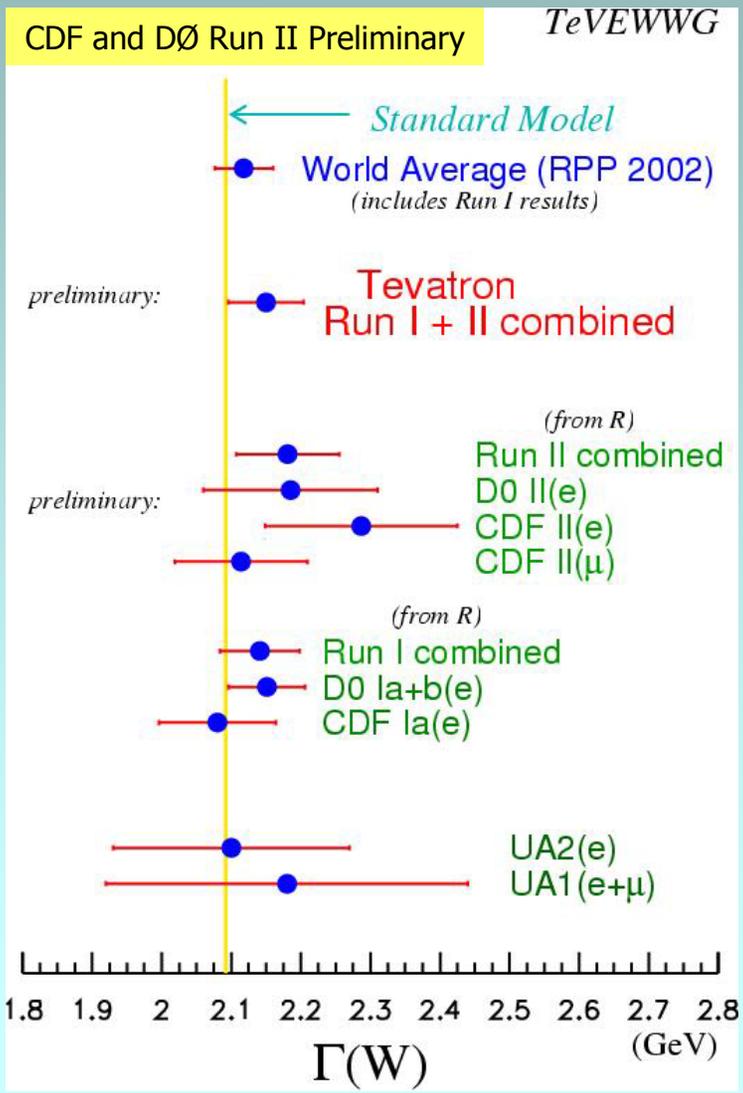




CDF- DØ Combined Results

<http://tevewwg.fnal.gov>

**Arrived
today!**



W-Mass Tevatron Run I Result

<http://tevewwg.fnal.gov>

- W Mass Tevatron Run I result (July 2002)

- DØ:

$$M_W = 80.483 \pm 0.084 \text{ GeV}$$

Run I

- CDF:

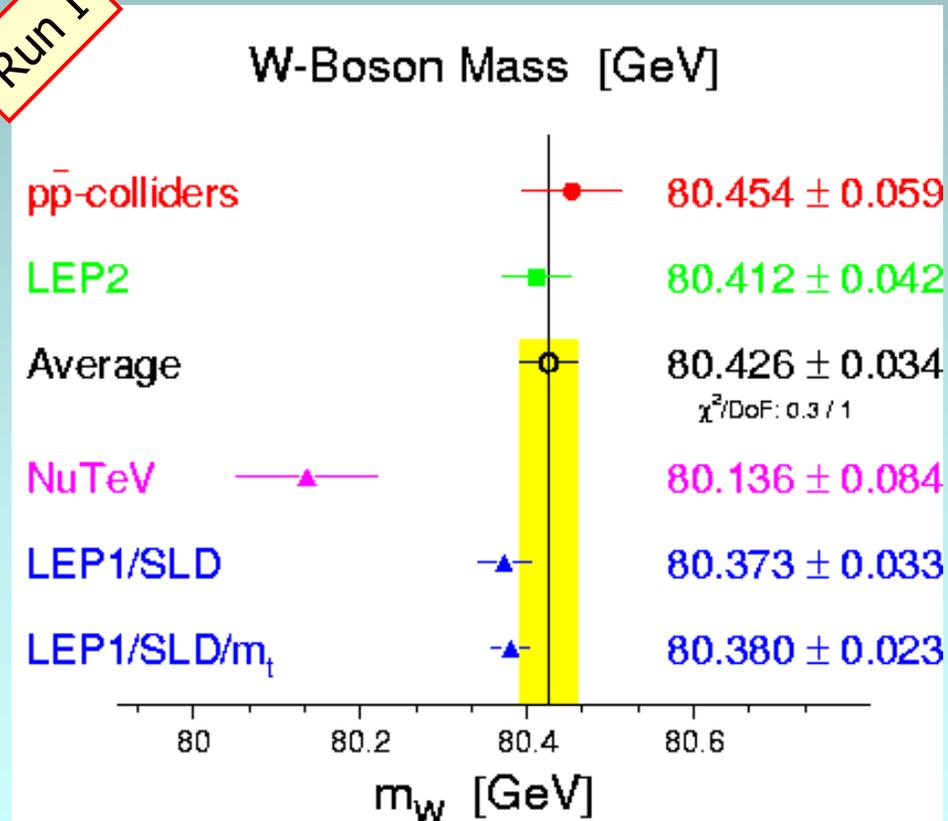
$$M_W = 80.433 \pm 0.079 \text{ GeV}$$

- Tevatron:

$$M_W = 80.456 \pm 0.059 \text{ GeV}$$

- World:

$$M_W = 80.426 \pm 0.034 \text{ GeV}$$

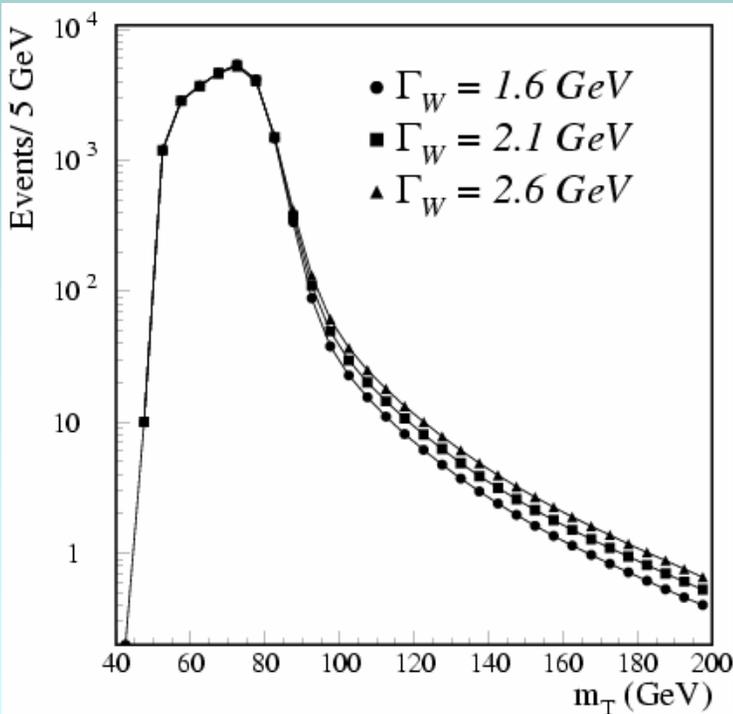




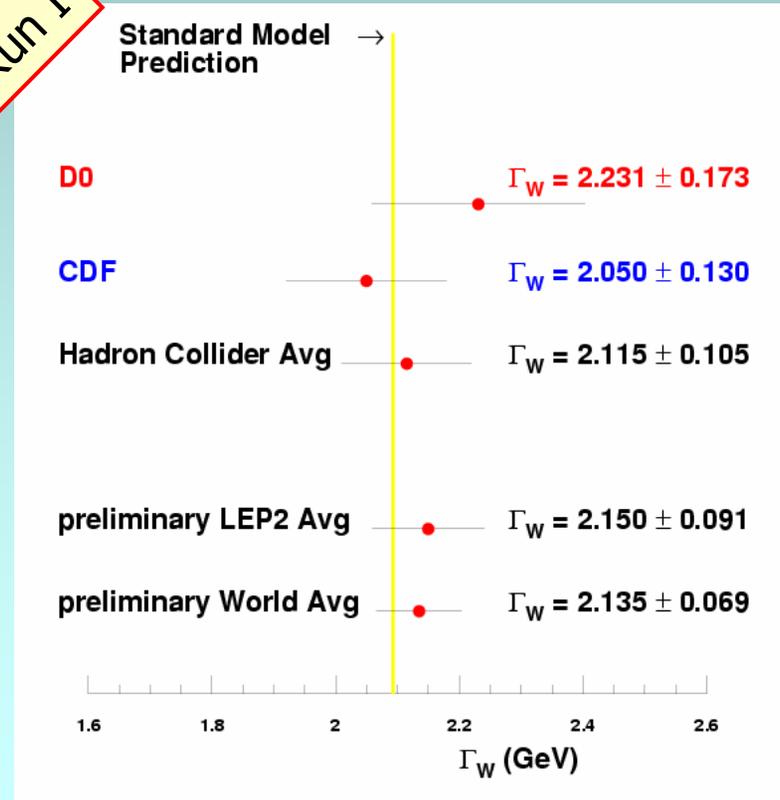
W-Width Tevatron Run I Result

<http://tevewwg.fnal.gov>

- Shape of transverse mass distribution for $M_T > 90$ GeV is affected by the W width – *Direct Method*
 - Electron channel



Run I

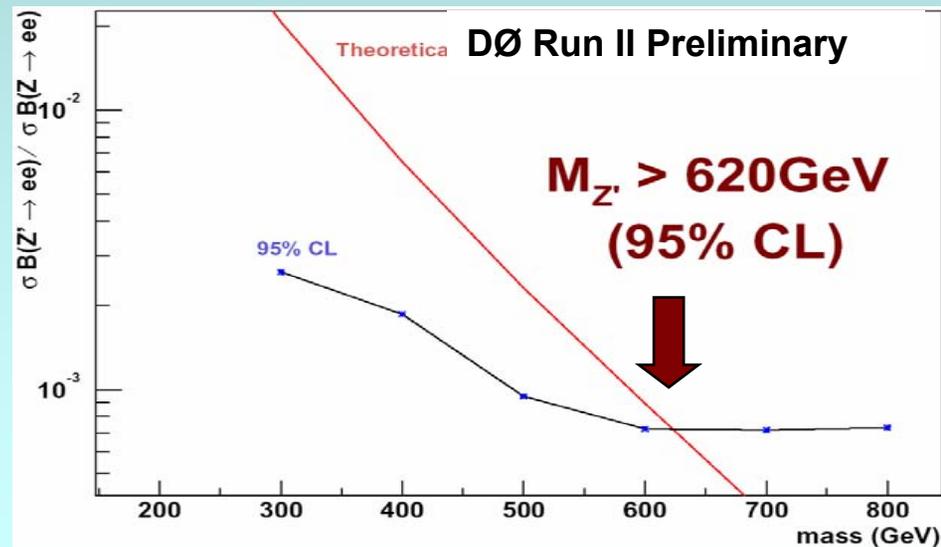
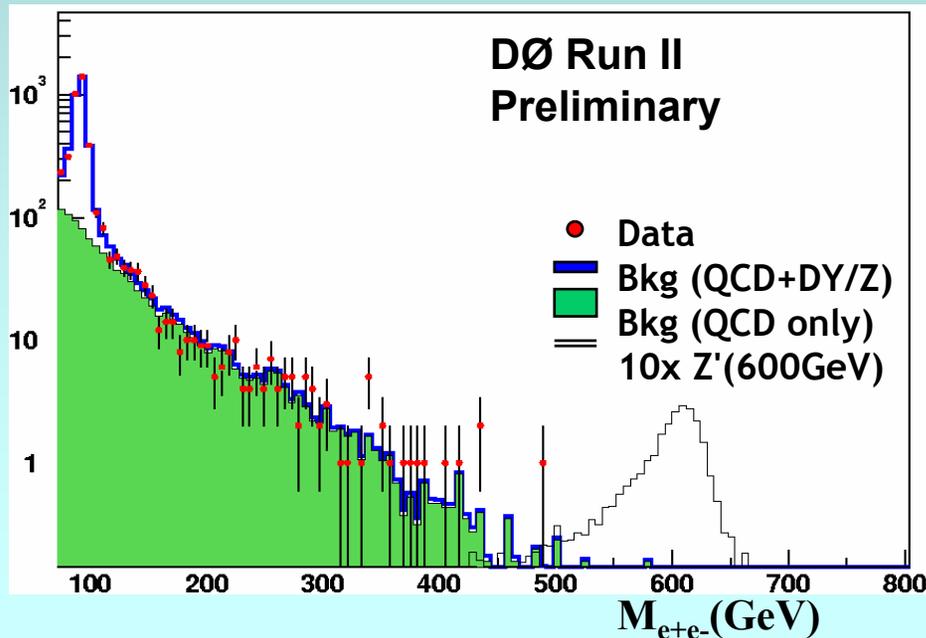




$Z' \rightarrow ee$ Search

- Search for non-SM heavy particles that decay to lepton pairs
 - Assume same quark/lepton couplings as SM Z
- $D\bar{O}$ Run I limit: $M_{Z'} > 670$ GeV
 - With 2 fb^{-1} sensitivity up to 1 TeV

$$L = 50 \text{ pb}^{-1}$$





Higgs Searches

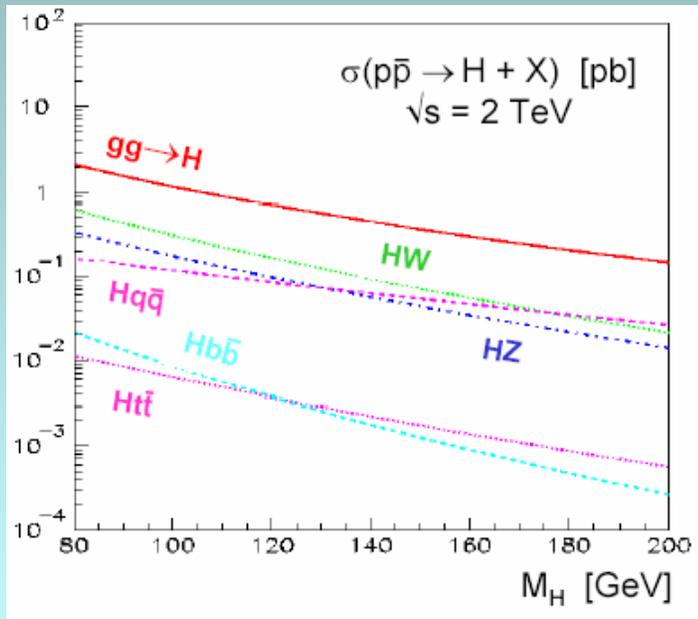
- SM Higgs Boson:
 - $m_H > 114.4$ GeV (95% CL) Direct searches by LEP
 - $m_H < \sim 200$ GeV Indirect result from fit to data
- Many additional Higgs bosons in other models
- Searches are underway at DØ
 - Several fb^{-1} of data needed for observation
 - Non SM processes enhance cross section
- Run II will provide stringent constraints to SM Higgs
 - $\delta M_t < 2.5$ GeV per exp (currently 5.1 GeV - combined)
 - $\delta M_W < 40$ MeV per exp (currently 59 MeV - combined)
- *See talk by Drew Baden on fermiophobic Higgs*
 - $H \rightarrow WW^*$, $H \rightarrow \gamma\gamma$





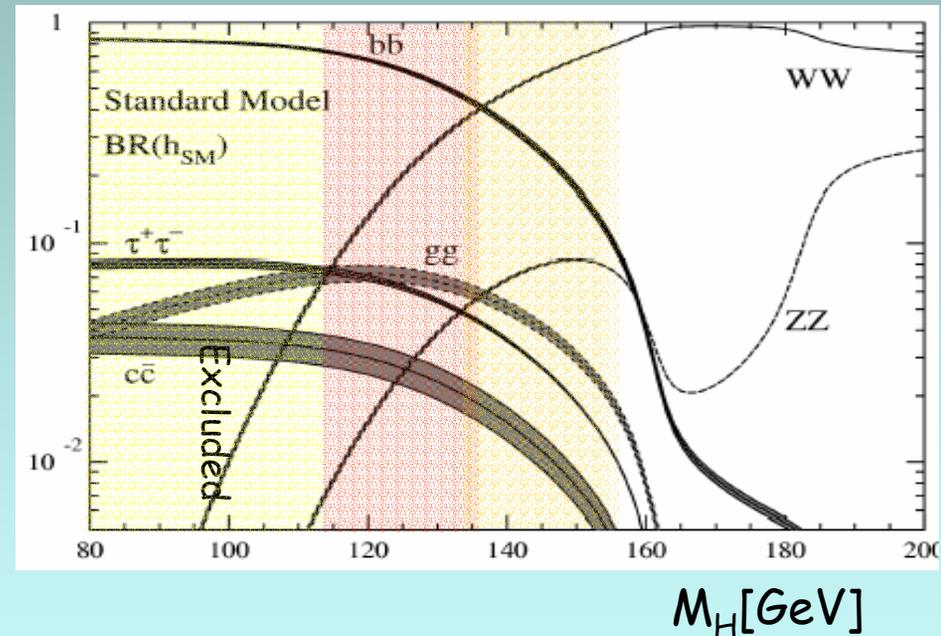
Higgs Decays

Search strategies are a function of Decay Channel and Production Channel



Low Mass Higgs Searches

$m_H < 135 \text{ GeV}$
 $ZH, WH \quad H \rightarrow b\bar{b}$



High Mass Higgs Searches

$m_H > 120 \text{ GeV}$
 $gg \rightarrow H \rightarrow WW^*$

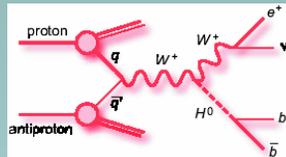




W(eν or μν)+Jets

Electron selection

- $|\eta_e| < 0.8, E_{Te} > 20$ GeV
- $\cancel{E}_T > 25$ GeV

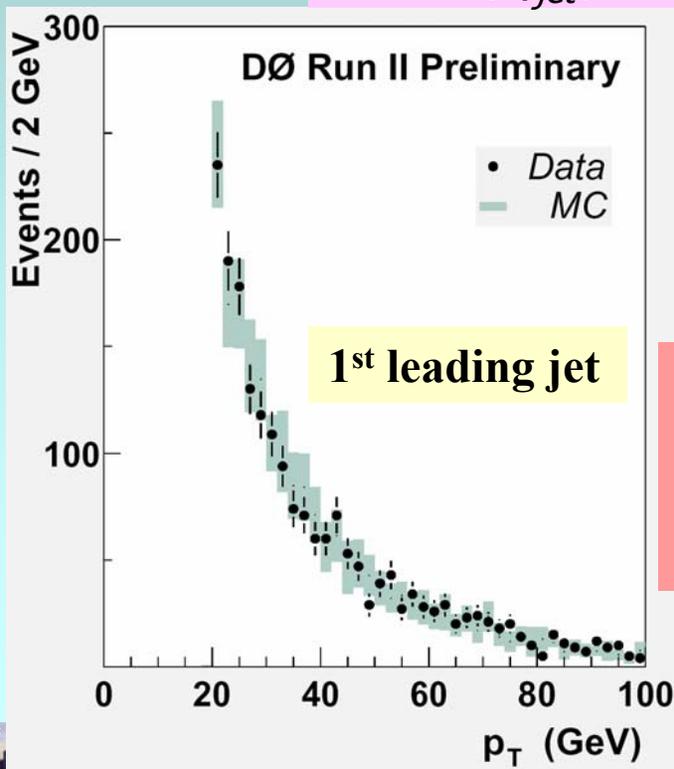


Muon selection

- $|\eta_\mu| < 1.5, p_{T\mu} > 25$ GeV
- $\cancel{E}_T > 20$ GeV

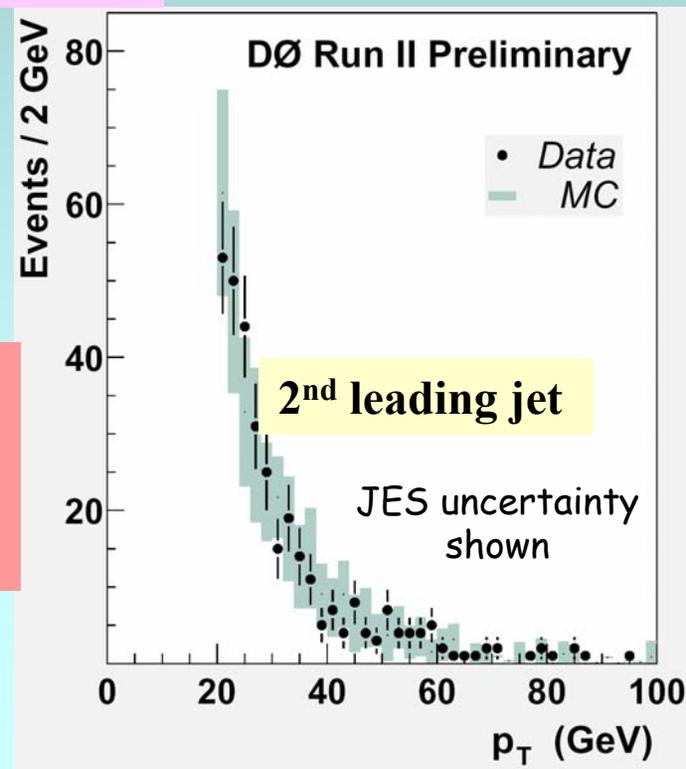
Jet selection

- $|\eta_{jet}| < 2.5, E_{Tjet} > 20$ GeV



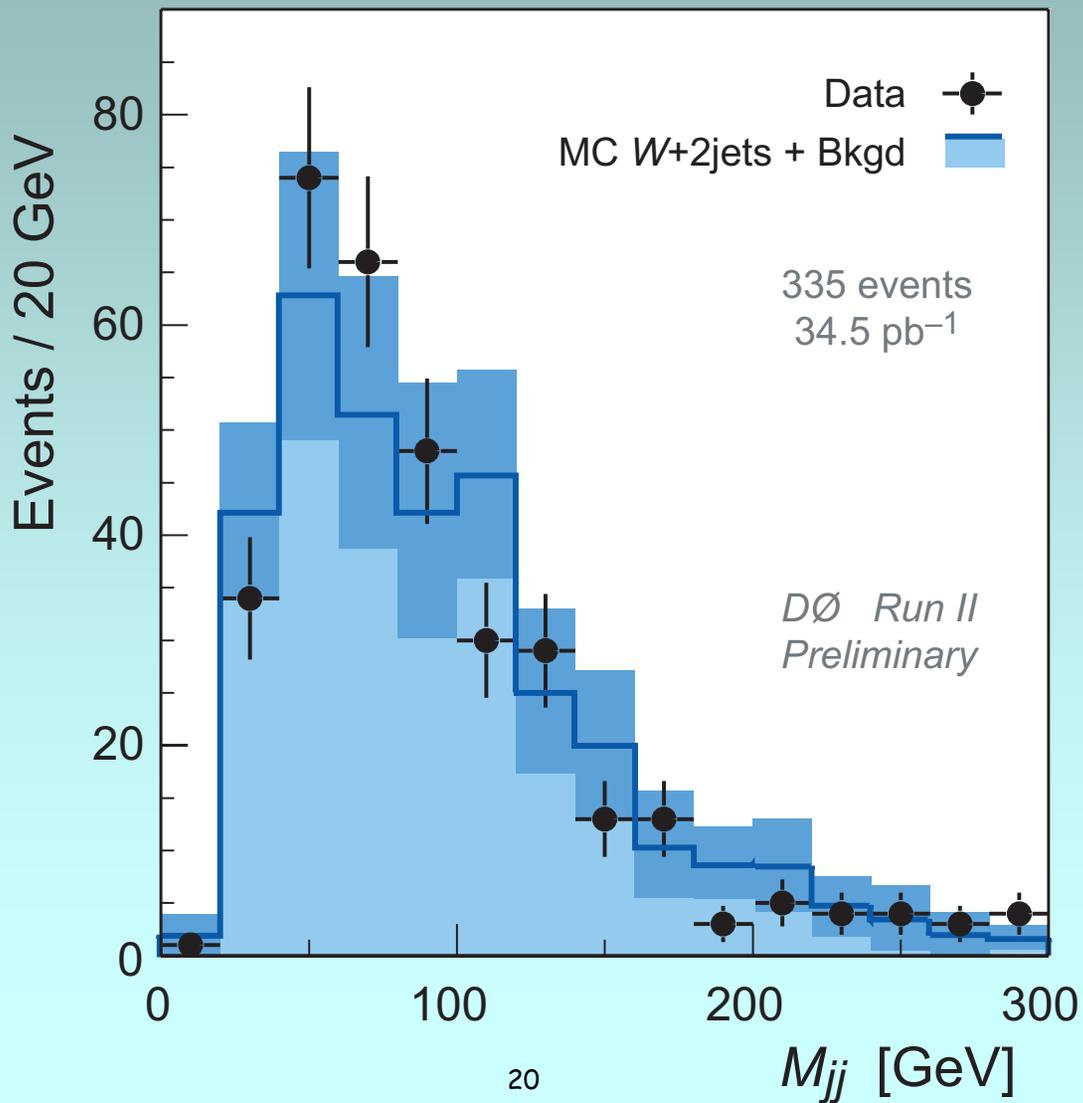
$W \rightarrow e\nu$
 $W \rightarrow \mu\nu$
 Combined

MC=PYTHIA
 +
 Detector
 Simulation





W(eν or μν)+Jets – Dijet Mass





Z(ee or $\mu\mu$)+Jets

Electron selection

- $|\eta_e| < 2.3, E_{Te} > 20$ GeV

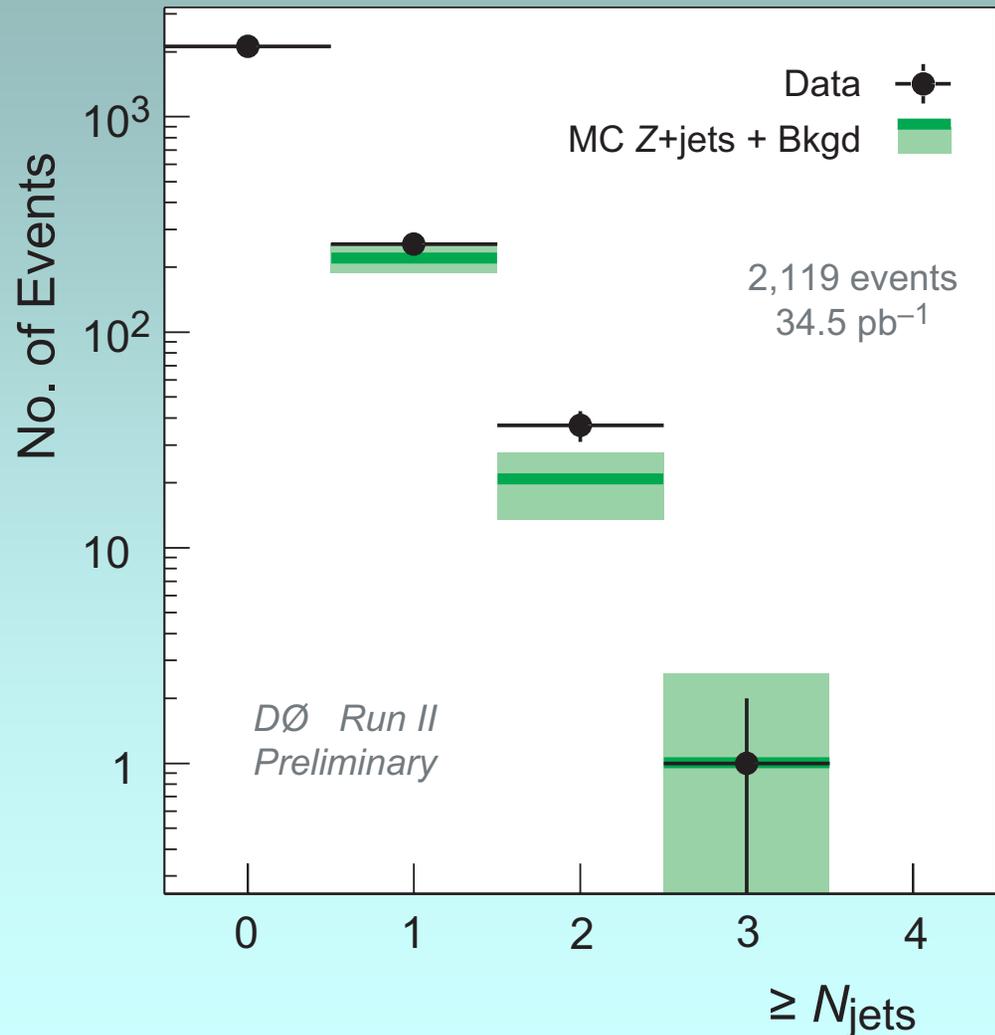
Muon selection

- $|\eta_\mu| < 2, p_{T\mu} > 15$ GeV

Jet selection

- $|\eta_{jet}| < 2.5, E_{Tjet} > 20$ GeV

**MC=PYTHIA
+
Detector
Simulation**



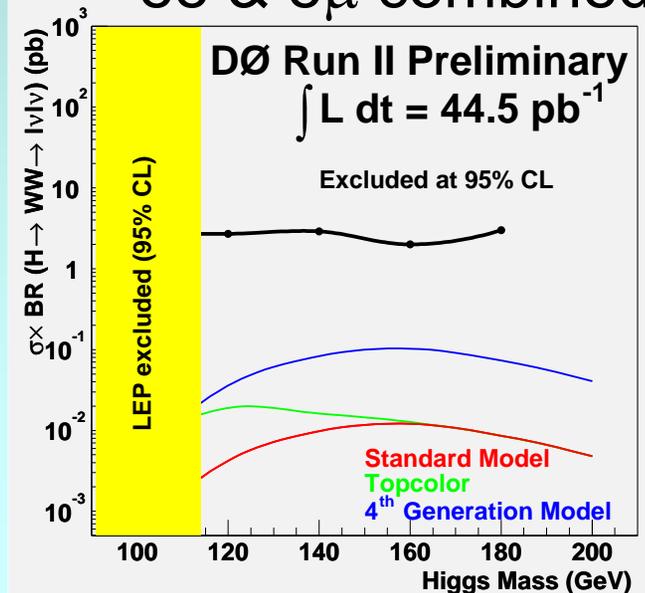


$$H \rightarrow WW^* \rightarrow \ell^+ \ell^- \nu \nu$$

- Search for high mass Higgs
 - SM extensions enhance the production cross section
- Signal: dileptons + \cancel{E}_T
- Bkgd: Z/γ^* , WW , $t\bar{t}$, $W/Z + j$, QCD
- Opening angle between leptons is useful discriminating variable
 - Two leptons tend to move in parallel due to spin correlation of Higgs boson decay products
- Excluded cross section together with expectations from SM Higgs production and alternative models.

	ee	eμ	μμ
\mathcal{L} (pb ⁻¹)	44	34	48
Total Background	0.7 ± 1.4	0.9 ± 1.5	0.3 ± 0.1 (stat)
Observed events	0	1	1

ee & eμ combined





Future Prospects

- Near term: expect at least doubling of analyzed data for late summer conferences
- Long term: reaching 4-8 fb⁻¹ by FY09
 - Detector upgrades for FY06 (Si, trigger)

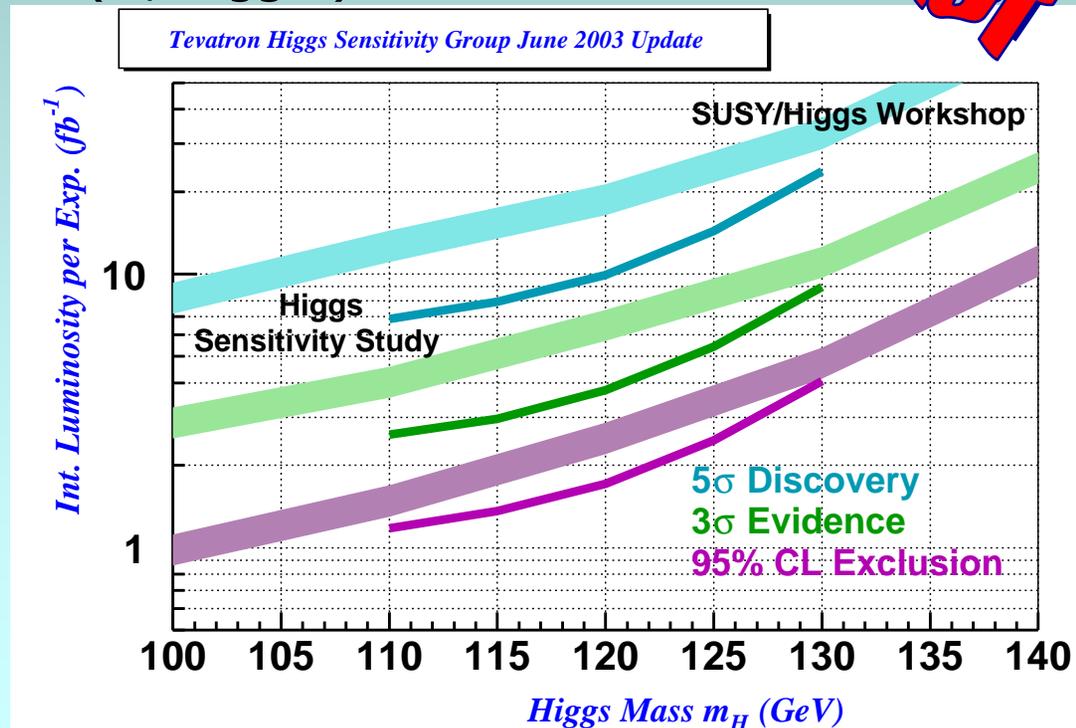


SUSY/Higgs Workshop:

hep-ph/0010338

Tevatron Higgs Sensitivity Group:
June 24, 2003

- WH → lvbb
- ZH → vvbb
- Improvement due mainly to sophisticated analysis techniques





Summary

- Presented results from the first 50 pb⁻¹ of Run II data
- New W and Z cross section measurements from DØ @ 1.96 TeV shown
 - First Tevatron combined W width results from Run II
- Results consistent with SM predictions
- Higgs studies are well under way
- Very exciting short and long term future prospects with a lot of hard work ahead

